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Substitute Specification

09/937996

JCO9 Rec'd PCT/PTO 2 8 SEP 2001

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STEERING DEVICE FOR VEHICLES

BACKGROUND

1. Technical Field

The present application is directed to a steering device for vehicles, and in particular to a steering device comprising a steering shaft, a sensor for determining the movement of the steering shaft, and a circuit for evaluating the measuring signals of the sensor.

2. Background of Related Art

Vehicle steering mechanisms may take different forms. Rack and pinion steerage is used particularly often. With rack steerage, a driver exerts a torque on a steering column via a steering wheel. Direct power transmission then continues via a pinion, i.e. a gear wheel, to a rack. Longitudinal movement of the rack results in longitudinal movement of a steering shaft in, or on which, the rack is mounted. The steering shaft in turn moves the steering gear, with the vehicle wheels arranged on it, and is steered in this manner.

To assist the direct power transmission by the driver it is also known to use hydraulic power-assisted steering mechanisms, in which a pressure chamber runs a piston fixed to the steering shaft. By controlling the pressure in the chamber filled with hydraulic oil the piston can be moved, thereby assisting the steering gear in addition to the power transmission by the driver. Alternatively, the pinion drive may be assisted by an electric motor.

In order to provide these various forms of assistance it is naturally desirable to have a measuring signal available which correlates with the state of the steerage. The signal could then take over appropriate control to boost the steering, for power-assisted steering and similar purposes, and could also allow

1 for self-regulating systems. Over and above the control of the servo mechanism,
2 allowance should also be made for boosting measures to optimise the steering and
3 attenuation action of motor vehicles or simultaneous control of all four wheels and
4 other intelligent steering systems.

5
6 Various proposals have already been made for obtaining a signal which
7 correlates with the state of the steerage.

8
9 Thus, it is proposed in DE 40 29 764 A1 to arrange length measuring
10 means between the steering wheel and the front axle, responding to displacement
11 of the steering rack. Inductive or ohmic devices are proposed for these means.
12 A design with two magneto-resistive sensors is known from EP 0 410 583 B1.
13 Here, the magnetic coupling is changed on movement of the steering shaft, thus
14 enabling the position to be determined. However, this involves changing the
15 geometry of the steering shaft and also providing it with a groove, which apart
16 from the expense, gives it a certain susceptibility to trouble. EP 0 376 456 B1 also
17 operates with a magnet which is arranged on the steering shaft and surrounded by
18 an induction coil. A change in induction can be associated with a change in
19 displacement.

20
21 Steering angle sensors operating with magnetic field sensors, so-called
22 Hall sensors, are known from DE 197 03 903 A1 and DE 197 52 346 A1.

23
24 These known proposals have the drawback that measurement only allows
25 restricted accuracy. Another problematic feature is that the measurements are
26 relative, so that measuring errors add up over time. The proposals are not,
27 therefore, practicable for use in intelligent steering systems.

1 It is known from DE 37 03 591 C2, in a rack steering mechanism at the
2 end of the steering column, to measure the rotary angle of the column by
3 appropriately acting on an induction coil or a piezo power-measuring cell.
4 However, the end of the steering column also carries the power transmission to the
5 steering rack and is both structurally confined and unfavourable for measurements,
6 particularly as a great deal of malfunctioning may take place there.

7
8 There is, therefore, needed in the art a steering device in which it is
9 possible to pick up a signal correlating with the state of the steering mechanism
10 and more suitable for controlling intelligent steering systems of that type.

11 SUMMARY

12
13 The present invention is directed to a steering device which includes coded
14 microstructures which are provided on the steering shaft and/or on a device that
15 is connected to the steering shaft in a non-positive manner; a sensor which detects
16 the microstructures and outputs associated measuring signals; and an electronic
17 circuit to which the measuring signals of the sensor are fed, and which outputs
18 electronic signals to control the steering.

19
20 The invention proposes a steering device for vehicles which allows
21 absolute measurements of position. Therefore, the disadvantages associated with
22 the state of the art no longer exist. The steering device according to the invention
23 is more accurate and supplies reproducible measuring signals. Regulation and/or
24 control of the movement of the steering shaft becomes possible, particularly for
25 intelligent steering systems.

26
27 Advanced surface techniques with processes indicating the microstructure
28 are thus combined with a high-resolution sensor, i.e. a detection system, with an

1 appropriate electronic circuit. The term "microstructures" refers here to structures
2 with dimensions in the micrometer range.

3
4 The term "detect" refers particularly to processes where contact-free
5 recognition takes place, preferably optically or magnetically. However, other
6 detection methods which read, sense, feel or otherwise recognise also come into
7 consideration.

8
9 The invention allows absolute determination of the position of the steering
10 shaft in a rapid, high-resolution and reliable manner, with resolution in the low
11 micrometer range. Falsification or trouble from electromagnetic fields or in the
12 region of the steering mechanism either does not take place or is negligible.

13
14 The invention may be applied successfully in particular to advanced, so-
15 called intelligent steering systems.

16
17 It is possible to equip the actual steering shaft with microstructures. The
18 disadvantage of doing so would be the difficulty of manipulating the whole shaft
19 during the fitting process. In order to avoid this, smaller, interchangeable
20 elements which can be non-positively connected to the steering shaft, e.g. in bar
21 form, may be appropriately equipped, then inserted.

22
23 The microstructures are advantageously formed so that they contain
24 suitable coding, allowing the position of the steering shaft to be determined
25 accurately.

26
27 The microstructures are preferably detected by optical scanning methods,
28 particularly using elements from microsystem technology. Microsystem
29 technology is understood here as the fields of microstructure technology, micro-

1 optics and fibre optics. Microlenses with diameters down to about 10 μm and
2 focal lengths of the same order of magnitude may be used. If glass or other fibres
3 and very small diameters are used, the microlenses can be fixed directly on the end
4 face of the fibres. The entire system may have Y branches and is integrated with
5 individual modules to form a compact microsystem. The modules may, if
6 appropriate, be spatially offset over the optical fibres - for example to allow
7 optoelectronic components and the evaluating electronic means to be operated
8 optimally within low-temperature ranges.

9
10 Tribologically suitable film systems are advantageously applied to the
11 steering shaft or to a linear means connected thereto without play, described as a
12 device or measuring device. This may be done by thin film processes which have
13 proved successful in other industrial fields. Special microstructures are produced
14 by high-resolution structuring and etching processes. The microstructures are
15 constituted so that they can be read by the sensors.

16
17 The optical contrast, i.e. the difference in reflectivity, of the
18 microstructures to the steering shaft surface below them may for example be
19 modified, so that the pattern can be optically recognised by means of miniaturised
20 fibre optical systems. Another example is to make the microstructures in the form
21 of a reflection hologram, with coding as in the previous example (segment-wise)
22 and with reading effected by a suitable miniaturised optical system. The
23 functional layer may be crystalline or amorphous and the hologram may be written
24 in a phase or angle code. The hologram may function in one frequency range
25 (monochromatic) or more than one (coloured), and the information may be written
26 (to the hologram) by a digital or analog process.

27
28 Other physical methods may be employed instead of, or as well as, optical
29 sensors or optically detectable microstructures. Thus, microstructures may also

1 be formed in magnetic films, e.g. CoSm or NdFeB. The sensors could then in
2 particular be magnetic sensors, otherwise used in data storage technology.

3
4 Microstructures are produced on the steering shaft or on the device non-
5 positively connected thereto in the form of incremental markings. Tribologically
6 optimised layer systems are preferred, using high-resolution lithographic or laser
7 technology methods suitable for three-dimensional applications. The lithographic
8 methods considered are of the photo, electronic, X ray and/or ionic type.

9
10 Multiple-layer or composite structures may equally be employed.

11
12 The patterns formed are preferably dimensioned in micrometers. The layer
13 systems, combined with an appropriate sensory recognition system, enable the
14 current position to be determined absolutely, to an accuracy of only a few
15 micrometers.

16
17 In an advantageous embodiment of the invention two complementary,
18 parallel patterns are provided with suitable coding, e.g. bit coding. In one
19 embodiment the marking structure comprises strips which are optically
20 distinguishable by reflection, the strip patterns containing binary L/O coding.

21
22 In this way the displacement-measuring system, which may be fully
23 integrated into the steering mechanism, can recognise the current absolute position
24 of the steerage in every operating phase by means of the bit coding.

25
26 Various patterns are possible. For example a dual code, a Gray code or
27 even stepped codes known *per se* from relevant mathematical processes may be
28 used.

1 It is particularly preferable to use optical sensors, especially fibre-optical
2 double sensors, for scanning the markings and microstructures. Multiple sensors
3 are also possible, especially in array form.

4
5 In a preferred method the microstructures are produced by applying thin
6 film techniques. These techniques are advantageously PVD (physical vapour
7 deposition) and/or CVD (chemical vapour deposition). As already mentioned,
8 structuring is effected by lithographical processes.

9
10 The microstructures can also be formed by dry etching and/or wet
11 chemical etching.

12
13 Alternatively, they may be made by laser beam techniques, e.g. direct-
14 writing laser ablation processes and/or laser-lithographic processes and/or direct-
15 action, mask-related laser structuring methods.

16
17 The microstructures are preferably built up from tribological hard-material
18 layered systems. Single or multi-layer films may be used. They are preferably
19 made of titanium nitride (TiN) and/or titanium aluminium nitride (TiAlN) and/or
20 titanium carbonitride (TiCN) films and/or aluminium oxide films and/or
21 amorphous diamantine hydrocarbon films with or without metal doping and/or
22 amorphous diamantine carbon films with or without metal doping and/or
23 amorphous CN films and/or cubic boron nitride films and/or diamond films.

24 25 26 BRIEF DESCRIPTION OF THE DRAWINGS

27 It should be understood that the drawings are provided for the purpose of
28 illustration only and are not intended to define the limits of the invention. The
29 foregoing and other objects and advantages of the embodiments described herein

1 will become apparent with reference to the following detailed description when
2 taken in conjunction with the accompanying drawings in which:

3
4 FIG. 1 is a diagrammatic section through elements of an embodiment of
5 a steering device according to the invention;

6
7 FIG. 2 is an alternative embodiment to FIG. 1;

8
9 FIG. 3 is a diagrammatic representation of a microsystem-type sensor
10 system for an embodiment of the steering device according to the invention;

11
12 FIG. 4 is a detailed representation of a member from FIG. 3;

13
14 FIG. 5 is a detailed representation of an alternative embodiment of that
15 member from FIG. 3;

16
17 FIG. 6 is a detailed representation of another member from FIG. 3;

18
19 FIG. 7 shows an example of a microstructure;

20
21 FIG. 8 shows an alternative embodiment of FIG. 7;

22
23 FIG. 9 shows another alternative embodiment of FIG. 7;

24
25 FIG. 10 is a diagrammatic section through a microstructure;

26
27 FIG. 11 shows the FIG. 10 embodiment after a possible further processing
28 step;

29

1 FIG. 12 is a diagrammatic section through another embodiment similar to
2 FIG. 10;

3
4 FIG. 13 is a diagrammatic section through a third embodiment similar to
5 FIG. 10;

6
7 FIG. 14 shows the FIG. 13 embodiment after a possible further processing
8 step; and

9
10 FIG. 15 is a diagrammatic representation of an embodiment of a sensor.

11
12 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

13 A first embodiment of a steering device according to the invention is
14 shown in FIG. 1, and includes a mounting block 10, inside which there is a
15 pressure chamber 11 containing hydraulic oil 12, the chamber 11 being nearly full
16 of oil 12 as shown. The oil 12 is under a pressure p. In FIG. 1 the mounting block
17 10 is represented purely diagrammatically; it is substantially cylindrical here, with
18 considerable proportions of the block extending out of FIG. 1.

19
20 The steering shaft 20 runs approximately along the cylinder axis of the
21 mounting block 10. It thus extends through the pressure chamber 11 with the
22 hydraulic oil 12. The shaft 20 is provided with a steering rack 21, indicated here
23 in FIG. 1 by corresponding tooth signs. The rack 21 is driven by a pinion 22. The
24 pinion is coupled to the steering mechanism of a vehicle (not shown). When the
25 steering wheel e.g. of a passenger car is turned the corresponding torque is
26 transmitted through the pinion 22 to the rack 21 and displaces the whole steering
27 shaft 20 with it along the axis through the mounting block 10.

1 A piston 23 is also seated on the steering shaft 20 with a non-positive
2 connection thereto. It is arranged inside the pressure chamber 11 and thus in the
3 hydraulic oil 12, whereas the pinion 22 and rack 21 are located outside the
4 chamber 11.

5
6 The steering shaft 20 thus passes through the wall of the pressure chamber
7 11 in two places. Both places are sealed by seals 24, preferably Viton seals. The
8 piston 23 moves along with the shaft 20 by virtue of its non-positive connection
9 thereto. It fills the entire cross-section of the chamber 11. The piston 23, and
10 thus the steering shaft 20, can consequently be moved by changes in the pressure
11 of the hydraulic oil 12. This is a common method of strengthening the forces
12 exerted by the user of the vehicle through the pinion 22.

13
14 Suitable diameters for steering shafts 20 are about 20 to 40 mm, suitable
15 diameters for pressure chambers 11 about 40 to 70 mm, steering shafts 20 may
16 e.g. have lengths of the order of 800 mm, and the length of the pressure chamber
17 11 may e.g. be 200 to 400 mm. Quite different dimensions may of course be
18 appropriate according to the requirements for the steering device, as would be
19 known to those of skill in the art.

20
21 A mounting bore 13 is formed in the mounting block 10 outside the
22 pressure chamber 11. It extends from the outer wall of the block 10 to the through
23 bore in which the steering shaft 20 is located. The mounting bore 13 contains a
24 sensor 35 which may for example comprise the ends of a fibreglass sensory
25 mechanism.

26
27 In this particular region the outside of the shaft 20 is provided with
28 marking 30. The marking 30 comprises microstructures 31 arranged on top of the
29 shaft 20. These are coded axially of the shaft 20 so that different bit patterns pass

1 below the sensor 35 when the shaft 20 moves longitudinally relative to the
2 mounting block 10. The signals from the sensor 35 are passed to an electronic
3 circuit 40 (not specifically shown in FIG. 1). The circuit 40 can then determine
4 and transmit the position of the shaft 20 relative to the block 10 from the readings
5 of the sensor 35.

6
7 Apart from the longitudinal movement of the shaft 20 other movements
8 of the shaft are not important for the steering mechanism. Hence nothing
9 concerning any rotation of the shaft 20 is shown in FIG. 1. Any versions which
10 ensure that the pinion 22 runs appropriately over the steering rack 21 are possible
11 here.

12
13 Another, alternative embodiment is shown in FIG. 2 in a view similar to
14 FIG. 1.

15
16 In FIG. 2 the mounting block 10 will again be recognized, along with the
17 pressure chamber 11 and hydraulic oil 12. The steering shaft 20 with the rack 21
18 again passes through the block 10 and chamber 11. Here too, the pinion 22 drives
19 the rack 21. A piston 23 which can move inside the pressure chamber 11 is also
20 seated on the shaft 20.

21
22 In contrast with FIG. 1, a mounting bore 13 is not only provided, but
23 another mounting bore 14 is also provided outside the pressure chamber 11.

24
25 This difference enables two sensors 35 and 36 to be provided. Redundant
26 or complementary microstructures 31 of the marking 30 or microstructures
27 double-coded in another form can, therefore, be read out. The sensors 35 and 36
28 are preferably fibre optic reflection ones. The light source for the reflection
29 sensors is formed by light-emitting diodes (LEDs), which are spectrally adapted

1 to the hydraulic oil 12 used in the pressure chamber 11. Pentosin may preferably
2 be employed as the hydraulic oil 12.

3
4 The pressure p of the hydraulic oil 12 in the pressure chamber 11 is
5 regulated by valves in a valve control housing (not shown).

6
7 The steering shaft 20 is sealed at the openings where it passes into and out
8 of the pressure chamber 11 by seals 24, for example Viton seals. It thus has a
9 central position corresponding to the steering angle 0° . This is indicated as central
10 position X_0 in FIG. 2. Movement respectively to the right and left then takes place
11 in the direction of steering shaft position $+X$ (right) and in direction $-X$ (left).
12 These respective end positions correspond to a linear stroke which may typically
13 be ± 75 mm. It results in different stop angles of the steering mechanism
14 according to the type of vehicle. The linear stroke may also be smaller, e.g. ± 50
15 mm in individual cases, according to the type of vehicle.

16
17 In FIG. 2, the two mounting bores 13 and 14 are arranged outside the
18 pressure chamber 11, so the two individual sensors 35 and 36 are also arranged
19 outside it. It is also possible to provide an integrated pair of sensors.

20
21 In another embodiment, the sensor or sensors 35 and 36 may be positioned
22 inside the pressure chamber 11. The sensor or sensors may then, for example, be
23 spaced from the steering shaft 20 and pick up the steering shaft data as an optical
24 sensor through the hydraulic oil 12.

25
26 This enables the sensor to provide information about the turbidity of the
27 hydraulic oil 12 in the chamber 11, as well as reading the microstructures 31 of
28 the marking 30 on the steering shaft 20. The information can be used as a
29 criterion for changing the oil 12. A suitable transmitting wavelength for the

1 optical sensor 35 is selected according to the turbidity and spectral absorption of
2 the oil 12. A system of this type operates even when dirty with abraded particles
3 or an oil film, and preferably has suitable redundancy, fault tolerance and
4 azimuthal tolerance for safety reasons.

5
6 The sensors may be fibre optic sensors with two individual fibres. As
7 indicated in FIG. 2, the fibres may be parallel or inclined to each other to absorb
8 incoming and reflected light (not shown). However, it is also possible to use fibre
9 optic reflection sensors in a Y structure or to take into account arrangements with
10 fibre lines or fibre bunches.

11
12 The sensors 35 and 36 or a sensor system 37 (see FIG. 3 for such a system)
13 are employed as transmitters or receivers and may be coupled direct to the fibres
14 by a particularly temperature-resistant installation and connection method.
15 Alternatively, they may be arranged over a feed fibre located in a lower-
16 temperature region. In another embodiment, the sensor module is fabricated as a
17 compact, miniaturised (microtechnical) module and mounted in the system in
18 order to simplify assembly.

19
20 In another embodiment (not illustrated) designed to increase reliability and
21 avoid malfunctioning, two sensors 35 are juxtaposed azimuthally. These then
22 sense two complementary bit patterns, both in the form of individual markings 30
23 applied by the thin film method and arranged parallel, with corresponding
24 microstructures 31.

25
26 An embodiment of marking 30 with microstructures 31 is shown
27 diagrammatically in FIG. 3. Here, the steering shaft 20 is reproduced purely
28 diagrammatically as a cut-out; it extends parallel with the x-direction indicated.
29

1 A sensor system 37 with an array of fibre optical Y branches 38 can further
2 be seen. It has a module "A" for generating and coupling the light 51 into the
3 input or coupling-in fibres 39 of the fibre optical Y branching element 38.

4
5 A module "B" is also provided, with an array arranged in the y-direction
6 of lenses 52, particularly microlenses, for generating parallel output beam pencils.
7 The output beam pencils 53 fall onto the microstructures 31 of the marking 30 on
8 the steering shaft 20. These microstructures 31 form a succession of sequences.
9 Position-specific selective retroflection takes place. The retroflected light passes
10 back through the lenses 52 into the fibres of module B and thence to a module C
11 for uncoupling and detecting the light 55 retroflected and leaving the fibre optical
12 Y branching element 38.

13
14 Moreover in FIG. 3:

15
16 $\pm x$ is the axial direction, i.e. the direction of movement of the steering shaft;
17 $\pm y$ is the azimuthal direction, i.e. the direction in which the position-specific
18 bit pattern is arranged; and
19 z is the direction in which the sensor system is installed.

20
21 Coordinates x and z are orthogonal to each other; coordinate z points in the
22 direction of the tangent to the surface of the steering shaft 20 which is orthogonal
23 to x and z.

24
25 FIG. 4 shows a detail from FIG. 3, namely a first version of a transmitting
26 and coupling-in module "A" with a single source 51, a single lens 52 and a
27 plurality of coupling fibres 39 of the Y branching element 38.

1 FIG. 5 shows an alternative to FIG. 4, a different version of a transmitting
2 and coupling-in module "A" with an array of lenses 52. The fibres are bunched
3 then separated again as coupling fibres 39 of the Y branching element 38.

4
5 FIG. 6 shows another detail from FIG. 3, namely an embodiment of an
6 uncoupling, reception and assessment module "C" with uncoupling fibres 54
7 bunched along a certain length, an array of lenses 52, a line of detectors 56, the
8 electronic circuit 40 with the electronic assessment means and the output signal
9 60 with the "position of the steering shaft".

10
11 FIG. 7 shows 8-bit coding in a radial direction and periodic displacement
12 marks in an axial direction.

13
14 FIG. 8 shows an example of an arrangement of blocks with individual
15 coding.

16
17 FIG. 9 shows an example of an arrangement of different structure
18 sequences and a guide structure with periodic division for tracking with azimuthal
19 displacement.

20
21 FIGS. 10 - 14 show embodiments of possible methods of producing the
22 microstructures 31. A coded pattern is produced on a basic member 81, which
23 may also be the steering shaft 20 or another device non-positively coupled thereto.
24 For a version where detection is to take place by optical blanking of the patterns
25 the basic member 81 is surface-treated with a focused laser beam, so that laser-
26 ablative processes at the point of action cause stripping and thus lasting marking
27 (cf. FIG. 10).

Eximer lasers are preferably used for this purpose, owing to their high resolution. The pattern thus produced can then be covered with a friction and wear-reducing film 82, as shown in FIG. 11. A metal-doped amorphous hydrocarbon film is well suited as such a covering film in the region of the steering shaft, and is preferably applied in a thickness of 0.5 to 5 μm by known plasma-supported PACVD processes (magnetron sputtering processes with a substrate bias and a hydrocarbon gas, preferably C_2H_2). Titanium or tungsten is preferably employed as the doping metal for this application. The metal-doped amorphous hydrocarbon layer may, for example, be produced using a Leybold large capacity sputtering plant, model Tritec 1000 with two tungsten targets installed. The plant has a rotary holder which can accommodate up to 20 steering shafts according to the equipment. After the normal pumping process whereby the chamber is pumped out to about 10^{-5} hPa, argon is admitted up to a pressure of 3×10^{-3} hPa and the substrate is surface-cleaned by ion bombardment at a bias potential of 100 to 300 V. The targets are pre-sputtered at about 6 KW in the process. A graded film of tungsten-doped hydrocarbon is formed without interrupting the plasma, by opening the target covers and successively adding C_2H_2 to the process. A few minutes later the C_2H_2 gas flow is adjusted to bring the ratio of tungsten to carbon in the layer to 5 - 10%. During the production of the metal-doped amorphous hydrocarbon film the substrates are coupled with a bias potential of from about 100 to 300 V, preferably 200 V. Under these conditions a film thickness of about 1 μm is applied in half an hour.

Other solutions explaining the use of a structured film are shown in FIGS. 12 - 14. The film structure may be utilized for different sensing principles. In the case of optical detection, film structures may e.g. have an appropriate contrast (surface or edge contrast) with the surrounding surface. The film structure may, however, be produced from a magnetic material and read by means of a magnetic

Claims

1. A steering device for vehicles, comprising a steering shaft (20), a sensor (35) for determining the movement of said steering shaft, and a circuit (40) for evaluating the measuring signals of the sensor (35), characterised in that coded microstructures (31) are provided on the steering shaft (20) and/or on a device that is connected to the steering shaft in a non-positive manner, that a sensor (35) is provided, which detects the microstructures (31) and outputs associated measuring signals, and that an electronic circuit (40) is provided, to which the measuring signals of the sensor (35) are fed and which outputs electronic signals for steering.

2. A steering device according to claim 1, characterised in that the microstructures (31) form a succession of sequences arranged in an axial direction on the steering shaft (20) and/or the device non-positively connected thereto.

3. A steering device according to claim 2, characterised in that each sequence comprises multiple and/or single structures arranged spatially in an azimuthal and/or axial direction and containing individual or block-type coding.

4. A steering device according to claim 2 or 3, characterised in that the sequences contain bit coding.

5. A steering device according to any of claims 2 to 4, characterised in that a plurality of sequences are combined in a block, the blocks being distinguishable from each other by coding.

6. A steering device according to any of claims 2 to 5, characterised in that

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the sequences arranged in an axial direction are present in redundant form, offset parallel more than once over the periphery of the steering shaft (20) and/or device.

7. A steering device according to any of the preceding claims, characterised in that the microstructures (31) are in complementary form.

8. A steering device according to any of the preceding claims, characterised in that the smallest details of the microstructures (31) have lateral dimensions of 5 nm to 5 mm.

9. A steering device according to claim 8, characterised in that the smallest details of the microstructures (31) have lateral dimensions of 1 μ m to 1 mm.

10. A steering device according to any of the preceding claims, characterised in that the microstructures (31) have a thickness of 5 nm to 1 mm.

11. A steering device according to claim 10, characterised in that the microstructures (31) have a thickness of 100 nm to 100 μ m.

12. A steering device according to any of the preceding claims, characterised in that the microstructures (31) have a level surface and are levelled by a planarising method.

13. A steering device according to any of the preceding claims, characterised in that the microstructures are built up from or covered with tribological hard-material layered systems.

14. A steering device according to claim 13, .

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characterised in that

the hard-material layered systems are single films or multi-layer films of TiN and/or TiAlN and/or TiCN films and/or aluminium oxide films and/or amorphous diamantine hydrocarbon films with and without metal doping and/or amorphous CN films and/or cubic boron nitride films and/or diamond films.

15. A steering device according to any of the preceding claims, characterised in that the sensors (35) are arranged in the form of a line and/or array.

16. A steering device according to any of the preceding claims, characterised in that the sensors (35) are optical sensors.

17. A steering device according to claim 16, characterised in that the sensors (35) are optical fibreglass sensors.

18. A steering device according to claim 17 characterised in that the sensors (35) are fibre-optical double or multiple sensors.

19. A steering device according to any of claims 16 to 18, characterised in that the microstructures are in the form of a reflection hologram.

20. A steering device according to any of claims 1 to 15, characterised in that the sensors (35) are magnetic sensors.

21. A steering device according to claim 20, characterised in that the magnetic sensors are in a linear arrangement for reading a multi-bit code, particularly an 8-bit code.

22. A steering device according to claim 20 or 21,

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characterised in that

the sensor (35) has a reading head with polar structures arranged on an arc matching the diameter of the steering shaft (20).

23. A method of making a steering device according to any of the preceding claims, characterised in that the microstructures on the steering shaft (20) or on the device non-positively connected to the shaft are produced using thin film methods, and that structuring is effected by photo-lithographic methods.

24. A method according to claim 23, characterised in that the thin-film method is a PVD and/or CVD method.

25. A method according to claim 23 or 24, characterised in that the microstructures are formed by a dry etching process and/or a wet-chemical etching process.

26. A method of making a steering device according to any of claims 1 to 22, characterised in that the microstructures are produced by a laser beam process.

27. A method according to claim 26, characterised in that the laser beam process used is a direct-writing laser ablation process and/or a laser-lithographic process and/or a direct-action mask-related laser-structuring process.

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Concluded